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EFFECTS OF EXPERIMENTAL PROGRAMS IN NINTH GRADE ALGEBRA ON PUPILS' SUBSEQUENT ENROLLMENT AND PERFORMANCE IN MATHEMATICS AND SCIENCE SUBJECTS. INTERIM REPORT.

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REPORT NUMBER BR-5-1028-IR-1 PUB DATE AUG 67
CONTRACT OEC-5-10-051
EDRS PRICE MF-$0.25 HC-$1.00 23P.

DESCRIPTORS- *CURRICULUM DEVELOPMENT, *EDUCATIONAL PROGRAMS, *MATHEMATICS, *SECONDARY SCHOOL MATHEMATICS, *SECONDARY SCHOOL SCIENCE, ACADEMIC ACHIEVEMENT, EXPERIMENTAL PROGRAMS, GRADE 9, GRADE 10, GRADE 11, BALL STATE, THE UNIVERSITY OF ILLINOIS COMMITTEE ON SCHOOL MATHEMATICS (UICSM), SCHOOL MATHEMATICS STUDY GROUP (SMSG), UNITED STATES DEPARTMENT OF HEALTH EDUCATION AND WELFARE.

AS PART OF A LARGER EVALUATION PROJECT, THIS RESEARCH EFFORT WAS ORGANIZED TO STUDY THE EFFECTS OF THE NEW MATH PROGRAMS ON HIGH SCHOOL PUPILS' SUBSEQUENT ENROLLMENT AND ACHIEVEMENT IN MATHEMATICS AND SCIENCE COURSES. THE PARTICULAR MATHEMATICS PROGRAMS INCLUDED IN THE STUDY WERE (1) THE BALL STATE TEACHERS COLLEGE PROGRAM, (2) THE UNIVERSITY OF ILLINOIS COMMITTEE ON SCHOOL MATHEMATICS (UICSM), AND (3) SCHOOL MATHEMATICS STUDY GROUP (SMSG). THE SPECIFIC QUESTION OF THE STUDY CONCERNED DIFFERENCES IN MATHEMATICS AND SCIENCE ENROLLMENTS BETWEEN STUDENTS IN ONE OF THE EXPERIMENTAL MATHEMATICS PROGRAMS AND STUDENTS IN CONVENTIONAL MATHEMATICS PROGRAMS. OTHER FACTORS CONSIDERED IN THE DATA ANALYSIS WERE THE GRADES THE STUDENTS EARNED IN NINTH GRADE MATHEMATICS AND THE PUPIL'S SEX. PUPILS IN A NUMBER OF SCHOOLS WERE ENROLLED IN NINTH GRADE ALGEBRA CLASSES IN WHICH ONE OF THE THREE EXPERIMENTAL PROGRAMS (E) OR A CONVENTIONAL (C) PROGRAM WAS BEING USED IN ALTERNATE CLASSES TAUGHT BY THE SAME TEACHER. INFORMATION WAS REQUESTED CONCERNING NINTH AND TENTH GRADE PUPIL ENROLLMENT AND FINAL GRADES AS WELL AS ELEVENTH GRADE ENROLLMENT IN EACH OF THE FOLLOWING AREAS--(1) MATHEMATICS, (2) LANGUAGE ARTS, (3) SOCIAL STUDIES, AND (4) SCIENCE. SOME EVIDENCE FAVORED THE CONCLUSION THAT THE BALL STATE AND UICSM PROGRAMS LED TO GREATER ENROLLMENTS IN TENTH GRADE MATHEMATICS, BUT NO DIFFERENCES IN SUBSEQUENT MATH AND SCIENCE PERFORMANCE WERE FOUND BETWEEN STUDENTS OF THE E OR C PROGRAMS. (DH)

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INTERIM REPORT

BR ~~Project~~ No. 5-1028

Contract No. OE-5-10-051

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U.S. DEPARTMENT OF
HEALTH, EDUCATION AND WELFARE

Office of Education
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The research reported herein was performed pursuant to a contract with the Office of Education, U.S. Department of Health, Education, and Welfare. Contractors undertaking such projects under Government sponsorship are encouraged to express freely their professional judgment in the conduct of the project. Points of view or opinions stated do not, therefore, necessarily represent official Office of Education position or policy.

Minnesota National Laboratory
Minnesota State Department of Education
St. Paul, Minnesota

Effects of experimental programs in ninth grade algebra on pupils' subsequent enrollment and performance in mathematics and science subjects.

James J. Ryan[1]

This study was carried out as part of a project investigating the effects of experimental programs in ninth grade algebra on attitudes and interests pupils develop toward mathematics.[2] The attitude project was conducted in conjunction with a more extensive project assessing the achievement effects of these experimental programs at all secondary grades.[3] The purpose of the study was to determine whether the experimental programs had a differential effect on pupils' enrollment decisions in subsequent years with respect to mathematics and related subjects.

A positive attitude or interest in an activity or subject such as mathematics is usually manifested by an individual's choosing to engage or participate in the activity or situations involving the activity when the opportunity is present to do so. Among the overt behavioral indications that a pupil could exhibit in the school situation that would represent an interest in a given subject matter area would be to choose to enroll in courses involving that subject when a choice is permitted. This is especially possible for mathematics since there is in most schools an advanced mathematics course at each grade level in high school in which the pupil can choose to enroll or not as he desires.

One indication therefore, of the effects of alternate instructional programs on pupil attitudes toward mathematics at the ninth grade level would be obtained from the enrollment in mathematics subjects during the subsequent years in high school on the part of pupils instructed with the different programs. Other things being equal, pupils instructed with programs contributing to a more positive attitude toward mathematics are more likely to enroll in mathematics subjects during the next and possibly the following years.

There are, of course, a number of factors of an extrinsic nature other than intrinsic pupil interest per se that influence or determine the subject choices pupils make in high school. Future educational plans and related requirements are no doubt predominant in such decisions with parents and teachers playing an influential role therein,usually encouraging enrollment. Nonetheless, there is no doubt a certain number of instances in which the extrinsic factors in both directions are about equally balanced for a pupil and his own attitudes and interests operate to determine the choice or resolve the decision. Because, for higher ability pupils the extrinsic factors would tend to be more heavily weighted toward enrollment, these instances would seem more likely to occur for pupils

1 The assistance of Shelby Hockert, JoAnn Youngren and Chaur C. Chen with the data processing and analyses is gratefully acknowledged.

2 "Effects of Modern and Conventional Mathematics Curricula on Pupil Attitudes, Interests and Perception of Proficiency," Office of Education Project 5-1028, Contract No. OE-5-10-051, James J. Ryan, Project Director.

3 "The Evaluation of Secondary Mathematics Curricula," supported in part by a grant (G 25164) from the National Science Foundation, Paul C. Rosenbloom, project initiator.

having somewhat lower mathematics proficiency or general academic ability. Presuming therefore, a reasonably equal or random distribution of pupils with respect to other influencing factors among alternate instructional programs, differences between them in proportion of pupils enrolling in subsequent mathematics subjects could be attributed to the effects of the program on the pupils' interest in mathematics.

Following the above reasoning, the level of a pupil's interest in mathematics might also influence his attitudes toward and enrollment decisions concerning other subjects in which mathematics is applied or which are concerned with quantitative concepts and relationships. Science subjects for the most part would seem to be in this category.

This study was carried out consequently to determine whether instruction with one of several experimental programs for ninth grade algebra affected enrollment in tenth and eleventh grade mathematics and science subjects.

The experimental programs were those developed under the auspices of Ball State Teachers College (Ball State), the University of Illinois Committee on School Mathematics (UICSM), and School Mathematics Study Group (SMSG).

The main question concerned the differences in enrollment in tenth and eleventh grade advanced mathematics and science courses between pupils previously instructed with one of the three experimental programs and those instructed respectively with the conventional program being used by the same teachers.

Two other factors relevant to enrollment in advanced mathematics were considered in the analysis, the grades the pupil earned in ninth grade mathematics and the pupil's sex. Probably the factor that most determines future enrollment in mathematics is the pupil's level of achievement as represented by the grades received in his last mathematics class. Also, as indicated above, an enrollment difference is more likely to be observed among lower than higher achieving pupils. In addition to individual differences in achievement, sex differences are also likely to occur with respect to enrollment in more advanced mathematics classes. Previous studies have observed sex differences with respect to the nature of educational goals, objectives, and aspirations of pupils as well as in attitudes toward mathematics. Consequently both pupil sex and ninth grade mathematics performance (grades) were taken into account.

A secondary question, which it was possible to examine in this context, was whether pupils instructed with the different programs in the ninth grade differed in their performance in the mathematics subjects in which they enrolled in the tenth grade. Other things being equal, the observation of subsequent performance or grade differences for pupils following alternate programs in the ninth grade would provide some indication of the relative effectiveness of the separate programs. This question was also examined with respect to tenth grade science subjects.

Method:

During the 1962-63 school year, as part of the larger project assessing achievement differences for the several experimental secondary mathematics programs, pupils in a number of schools were enrolled in ninth grade algebra classes in which either

one of the three experimental (E) or a conventional (C) program was being used in alternate classes taught by the same teacher. The textbooks used for and defining the respective experimental programs were: Ball State, Algebra I by Brumfrel, Eicholz and Shanks, Addison-Wesley, Mass. 1961; UICSM, High School Mathematics Units 1-4, University of Illinois Press, Urbana, Illinois 1962; SMSG First Course in Algebra, School Mathematics Study Group, Yale University Press, New Haven, Conn., 1962. During the 1964-65 school year, these schools were contacted with a request for grade and enrollment information for the pupils that had been instructed in the E and C classes two years previously.

Information was requested concerning pupil enrollment and final subject grades during the ninth and tenth grades and for enrollment during the eleventh grade. (Pupils had not completed eleventh grade at the time the data was gathered). Enrollment and grade information was obtained for each of the following subject matter areas: mathematics, language arts (English or literature), social studies and science.

This information was requested from the schools for 32 pairs of classes - one experimental and one conventional class being in each school. The number of experimental classes (and the number of teachers) in each of the experimental program conditions for which information was requested and the number for which usable information was obtained for both classes is shown in Table 1.[4]

Table 1

Number of Pairs of E and C Classes
For Whom Enrollment and Grade Data was Requested
and Included in the Analysis for Each E Program Comparison Condition

E Program	Requested	Included
Ball State	9	7
UICSM	11	5
SMSG	12	9
Total	32	21

During each of the two years following the ninth grade, a pupil could choose to enroll in none, one, or two additional mathematics subjects. Furthermore, among those enrolling in one additional mathematics subject over the two years, it was possible to do so either in the tenth or eleventh grades. For purposes of this study the distinction between enrollment in the tenth or the eleventh grade is of some relevance since in general, any differential effects of ninth grade instructional conditions on attitudes toward mathematics would most likely be reflected in enrollment decisions made for the tenth grade rather than for higher grades. Enrolling in an additional mathematics subject at the next opportunity rather than doing so after a year's delay would seem to be in itself one indication of a possible attitude difference developed during the immediately preceding year.

[4] Some schools did not respond to the request, others were only able to provide limited information concerning subsequent enrollment and grades.

Therefore, comparisons with respect to enrollment in tenth grade mathematics subjects independent of the eleventh grade enrollment, would appear to provide the most sensitive and direct indication of pupil attitudes as manifested in enrollment decisions subsequent to the ninth grade and consequently, would be the comparison most relevant to this question. Separate comparisons considering eleventh grade enrollment were also made however to determine the more general enrollment effects of the ninth grade instructional programs.

With respect to enrollment in advanced mathematics in the tenth or eleventh grades, either geometry, advanced or higher algebra, trigonometry or solid geometry were considered as advanced mathematics subjects. Neither re-enrollment in elementary algebra (due to previous failure) nor general or commercial mathematics were considered advanced mathematics subjects.

To take ninth grade performance into account, the overall distribution of grades for all pupils was determined. An A, B vs C, D division provided a division closest to the median and served therefore as the basis for classifying pupils with respect to level of performance for analysis purposes. Similarly, to control for and assess possible sex differences, the comparisons were made separately for males and females within the separate performance levels and for instructional condition or treatment (i.e. E or C) classifications.

In the analysis pupils in the respective E and C classes for teachers following the same E program were combined to provide separate comparisons for each of the three experimental program conditions. The pupils in the C classes taught by each teacher in addition to their E class served in effect as controls respectively for those in classes instructed with each E program.

With respect to science subjects, enrollment and grade comparisons were made only for the tenth grade. It was felt that it would be quite unlikely that ninth grade mathematics would have an effect on enrollment in eleventh grade science subjects because of the even larger number of intervening factors than would be the case for mathematics. The subjects treated as science subjects were general, physical or biological science, physics, biology and chemistry.

Results

Enrollment in 10th grade mathematics

Table 2 shows the tenth grade mathematics enrollment frequencies for E and C class pupils in each E program comparison condition. The reliability of the E-C enrollment differences (i.e. the probability that the differences were due to chance) within each performance level for the sexes separately and combined was determined using χ^2 or an exact probability test.

Among pupils who had performed or achieved at a relatively higher level in the ninth grade (grades of B or better), a very large proportion continued to enroll in mathematics subjects in the tenth grade. This tendency appeared equally strong for pupils in E and C classes in each of the E program comparison conditions.

Among pupils who had performed or achieved at a relatively lower level in the ninth grade (grades of C or D), a greater proportion of the E class boys in the

TABLE 2

Enrollment in tenth grade mathematics subjects for pupils in E and C classes for each E program comparison condition.

E program		BALL STATE						UICSM						SMSG					
Ninth grade math performance level		Low			High			Low			High			Low			High		
Instructional treatment		E	C		E	C		E	C		E	C		E	C		E	C	
Males	Enrolled	28	15	43	30	35	65	31	17	48	25	18	43	37	39	76	53	61	114
	Not enrolled	8	24	32	2	5	7	7	17	24	2	3	5	19	23	42	0	3	3
		36	39	75	32	40	72	38	34	72	27	21	48	56	62	118	53	64	117
		$\chi^2 = 10.3$[a]			p = .33[b]			$\chi^2 = 6.69$			p = .40			$\chi^2 = .03$			p = .16		
		p < .01						p < .01						p < .90					
Females	Enrolled	17	12	29	36	31	67	24	16	40	28	24	52	31	22	53	70	52	122
	Not enrolled	14	12	26	12	6	18	6	14	20	5	3	8	19	27	46	11	12	23
		31	24	55	48	37	85	30	30	60	33	27	60	50	49	99	81	64	145
		$\chi^2 = .01$			$\chi^2 = .51$			$\chi^2 = 3.68$			p = .25			$\chi^2 = 2.26$			$\chi^2 = .38$		
		p > .90			p < .50			p < .10						p < .20			p < .60		
All pupils	Enrolled	45	27	72	66	66	132	55	33	88	53	42	95	68	61	129	123	113	236
	Not enrolled	22	36	58	14	11	25	13	31	44	7	6	13	38	50	88	11	15	26
		67	63	130	80	77	157	68	64	132	60	48	108	106	111	217	134	128	262
		$\chi^2 = 6.81$			$\chi^2 = .11$			$\chi^2 = 11.47$			$\chi^2 = .03$			$\chi^2 = 1.54$			$\chi^2 = .55$		
		p < .01			p < .80			p < .001			p < .90			p < .30			p < .50		

[a] All χ^2 values computed using Yates correction.

[b] Where only probability values are shown, the exact probability of an E-C distribution difference as large or larger than obtained was determined.

Ball State and UICSM programs and E class girls in the UICSM and SMSG programs tended to enroll in tenth grade mathematics than did their respective C class counterparts. For the Ball State and UICSM boys, the frequency differences were highly reliable while neither of the E program comparisons for the girls reached the .05 level of significance.

Comparisons made with both sexes combined also showed that among lower performing pupils a significantly higher proportion of those in the C classes enrolled for both the Ball State and UICSM programs. It is evident, however, that the latter difference for the Ball State program is due only to the large difference in this regard for boys rather than girls while for the UICSM comparison both sexes contributed to the difference.

It appears then that a greater proportion of boys instructed with the Ball State program and of both sexes instructed with the UICSM program enrolled in tenth grade mathematics subjects than did comparable pupils instructed with conventional programs.

Although the E-C comparisons were made between pupils grouped according to their ninth grade performance level, performance differences between E and C class pupils may still have existed within the two levels or categories that were used. If for the pupils in the low performance level, a greater proportion of those in the E classes had C grades, while a greater proportion of those in the C classes had grades of D, this could account for the observed tenth grade enrollment differences.

Comparisons among the lower performance E and C class pupils for those receiving grades of C and D are shown in Table 3.

Table 3

Frequency of C and D Grades Received by Low Performance E and C Class Pupils

		Males			Females		
	Grade	C	D		C	D	
Ball State	E	31	5	36	26	5	31
	C	29	10	39	17	7	24
		60	15	75	43	12	55
		n.s.[a]			n.s.		
UICSM	E	25	13	38	17	13	30
	C	19	15	34	25	5	30
		44	28	72	42	18	60
		n.s.			C > E[b]		
SMSG	E	33	13	46	35	15	50
	C	40	22	62	37	12	49
		73	35	108	72	27	99
		n.s					

[a] non significant, $p > .10$ by χ^2 test.

[b] C class had higher proportion C grades.

The comparisons shown in Table 3 indicate that there were no instances in which a significantly higher proportion of E class pupils had received C grades. Consequently, it does not appear that the observed enrollment differences resulted from differences between E and C class pupils in the actual grades they had received the previous year.

Independent of the pupils relative performance level, the grades received in ninth grade algebra, other factors relevant to enrollment in tenth grade mathematics classes which could differ for E and C class pupils were the pupils level of ability or proficiency in mathematics as well as his general academic ability and attitudes toward academic achievement. It is possible that in the E classes there was a greater proportion of pupils having higher ability in mathematics, higher general academic ability, and/or a more positive attitude toward mathematics or academic achievement generally. A difference in favor of the E classes with respect to any or all of these factors (which tend to be related) may have occurred either accidentally or even to some extent intentionally or systematically. The latter possibility seems quite likely because of the characterization of the experimental or "modern" programs as being primarily for "college-bound" pupils. For this as well as other reasons, there may have been a greater tendency to shunt "less promising" pupils (as inferred from previous math class or general academic performance) into the conventional classes. These factors could operate independent of the performance measure (grades) if teachers were assigning grades <u>within classes</u> on a relative rather than a more absolute basis.

Data was not available to examine the question concerning the pupils general academic ability nor his attitudes or motivation to achieve either in mathematics in particular or in school generally. However, if proficiency differences did exist between pupils in E and C classes independent of the grades received, these differences should be reflected on a proficiency test measure (Mathematics Section, Sequential Tests of Educational Progress, Level 2[5]) obtained for a large proportion of these pupils at the beginning of the ninth grade. Here again this question is only of consequence for pupils in the lower ninth grade performance level, since it was only for pupils in this category that there was a reasonable nonenrollment proportion to provide a basis for comparison. To determine if measured proficiency could account for the enrollment differences among lower performance pupils, comparisons with respect to enrollment were made separately for those above and below the median on the proficiency test as obtained for the males and females separately.

Table 4 shows the separate enrollment frequencies of the E and C class pupils for those at the two levels on the mathematics proficiency test.

Two points are evident in the Ball State and UICSM comparisons. One is that there was a greater proportion of relatively higher proficiency pupils in the E than in the C classes. Comparisons between the proportions of E and C class pupils above and below the test median shown as marginal totals indicates that the differences in this respect for the Ball State males ($\chi^2 = 6.8$, $p < .01$) and females ($\chi^2 = 4.2$, $p < .05$) and for the UICSM pupils (both sexes combined, $\chi^2 = 3.8$, $.05 < p < .10$) are quite reliable.

5 <u>Sequential Tests of Educational Progress</u>, Cooperative Test Division, Educational Testing Service, Princeton, New Jersey. 1957.

TABLE 4

Tenth grade mathematics enrollment frequencies for low ninth grade performance pupils in E and C classes within levels of mathematics test proficiency.

Test level	Below median						Above median					
Sex	M			F			M			F		
Program	E	C		E	C		E	C		E	C	
Ball State:												
Enrolled	6	7	13	5	6	11	17	7	24	7	2	9
Not enrolled	2	13	15	8	10	18	4	4	8	6	1	7
	8	20	28	13	16	29	21	11	32	13	3	16
	p = .07			n.s.[a]			n.s.			n.s.		
UICSM:												
Enrolled	8	7	15	7	6	13	14	5	19	9	4	13
Not enrolled	7	12	19	2	6	8	0	2	2	4	3	7
	15	19	34	9	12	21	14	7	21	13	7	20
	n.s.			n.s.			n.s.			n.s.		
SMSG:												
Enrolled	15	13	28	13	11	24	20	19	39	18	6	24
Not enrolled	10	13	23	12	15	27	9	9	18	7	9	16
	25	26	51	25	26	51	29	28	57	25	15	40
	n.s.			n.s.			n.s.			$\chi^2 = 3.42$		
										$.05 < p < .10$		

[a] n.s. = non-significant, i.e. $p > .10$, as determined by χ^2 or an exact probability test.

It is also apparent that even within the proficiency levels a greater proportion of the Ball State males and UICSM males and females enrolled in tenth grade mathematics subjects. This tendency is somewhat stronger for those in the below median category, although for none of these comparisons did the difference reach the .05 level of significance.

For the SMSG program comparison, there is neither a difference between the E-C classes with respect to test proficiency level nor within proficiency levels with respect to the proportions enrolling in tenth grade mathematics.

In general, it appears that the enrollment differences observed for the Ball State males and the UICSM males and females were due in part but not totally to existing differences in mathematics proficiency as indicated by test scores which were somewhat independent of the grades pupils received. Apparently for the E-C class pairs in the Ball State and UICSM comparisons, the E class pupils had on the average a higher level of proficiency which was not, however, reflected in the grades they received.

Enrollment in tenth and eleventh grade mathematics subjects

Although the enrollment decision made at the tenth grade level would seem to provide the most sensitive indication in terms of enrollment of the effects of a ninth grade instructional program, some additional indications might be provided by considering enrollment in eleventh grade mathematics subjects.

Taking tenth and eleventh grade enrollment possibilities into account, there are several alternate enrollment sequences subsequent to ninth grade:

a) no further enrollment in tenth and eleventh grades

b) enrollment in eleventh grade only

c) enrollment in tenth grade only

d) enrollment in both tenth and eleventh grade

Enrollment in additional math courses beyond the tenth grade (categories [c] and [d] above), however, is no doubt influenced at least as much by the pupils' experience in his tenth grade class as his experience in ninth grade. Consequently, E-C comparisons with respect to categories (a) and (b) would appear to provide a more meaningful reflection of the effects of the ninth grade program, therefore eleventh grade enrollment comparisons were made separately for those who did and did not enroll in mathematics in the tenth grade, i.e. for those in categories (c) and (d) and those in categories (a) and (b), respectively.

Since for the previous analysis the mathematics test scores provided a more sensitive control for proficiency differences, the eleventh grade enrollment comparisons were made within levels of performance on the test measure of proficiency in mathematics obtained at the end of the ninth grade rather than the pupils' grades.

Advanced mathematics enrollment frequencies for males and females above and below the median of the distribution of the proficiency test scores for each of the possible enrollment sequences are shown in Table 5. (This table includes only those

TABLE 5

Frequency of enrollment in tenth and eleventh grade mathematics subjects for E and C class pupils within post ninth grade mathematics test proficiency levels.

	Test level	Below median				Above median			
	Sex	M		F		M		F	
	Program	E	C	E	C	E	C	E	C
	Grade enrolled								
Ball State	9	1	12	10	10	0	2	1	1
	9 & 11	3	6	4	3	3	4	7	2
		4	18	17	13	3	6	8	3
	9 & 10	5	2	9	6	12	12	8	10
	9, 10, & 11	9	7	10	3	26	17	13	13
		14	9	19	9	38	29	21	23
UICSM	9	7	12	7	8	0	1	2	3
	9 & 11	0	3	4	3	1	3	0	0
		7	15	11	11	1	4	2	3
	9 & 10	9	10	15	15	8	6	11	12
	9, 10, & 11	9	2	5	3	26	14	14	9
		18	12	20	18	34	20	25	21
SMSG	9	8	13	14	23	6	6	8	3
	9 & 11	1	0	0	3	0	0	1	6
		9	13	14	26	6	6	9	9
	9 & 10	9	10	18	15	6	7	14	9
	9, 10, & 11	16	16	18	15	37	30	29	13
		25	26	36	30	43	37	43	22

for whom actual enrollment decisions at both the tenth and eleventh grades were known, i.e., those who remained in the school system from the ninth grade into the eleventh grade.) Comparisons between the enrollment frequencies for E and C class pupils were made within sex by proficiency level categories using either Chi-square or an exact probability test.

For pupils not enrolled in tenth grade mathematics only one difference was reliable with a statistical probability of .10 or less. Higher proficiency girls who had been instructed with the SMSG program showed a significantly lower ($p < .03$) frequency of eleventh grade enrollment than comparable girls instructed with the conventional program. There were no similar tendencies indicated at the eleventh grade level for other pupils instructed with the SMSG program nor was this tendency observed for SMSG pupils for tenth grade enrollment.

Among pupils who had enrolled in tenth grade mathematics, the only E-C difference in eleventh grade enrollment reaching the .10 level of probability was that for the lower proficiency UICSM boys ($p < .08$) who had a higher frequency of enrollment relative to those in the conventional comparison classes. The latter difference appears to be a continuation of a tendency observed at the tenth grade level.

In general, there was little evidence that eleventh grade mathematics enrollment decisions were influenced to any real extent by the specific program of instruction at the ninth grade level when comparisons were made considering pupil proficiency in mathematics. The only exception was for the girls instructed with the SMSG program. However, in view of the lack of similar differences for other comparisons for the SMSG program these results appear to be too specific to provide the basis for any broad generalization in this regard.

Enrollment in tenth grade science subjects

To determine if the instructional program followed in ninth grade algebra may have influenced enrollment decisions for subjects other than mathematics which were likely to utilize mathematics or to involve quantitative concepts and relations, comparisons were made between E and C class pupils with respect to enrollment in science subjects in the tenth grade.

To control for the possible effects of grades received in previous science subjects, comparisons were made separately for pupils who had received a grade of B or better and C or less in their ninth grade science subjects.

Table 6 shows the tenth grade science enrollment frequencies for the sexes separately within the two levels of ninth grade science performance. Either Chi-square or the exact probability test was used to determine the reliability of the E-C differences in enrollment frequencies.

For the Ball State and SMSG program comparisons, none of the E-C enrollment differences reached the .05 level of probability. For the UICSM program, however, lower ninth grade performance boys and higher performance girls (and both sexes combined) showed a reliably lower frequency of enrollment than conventional class pupils. Since this analysis included only pupils who had been enrolled in ninth grade science a further comparison was made for pupils in the Ball State and SMSG programs

TABLE 6

Enrollment in tenth grade science subjects for pupils in E and C classes for each E program comparison condition.

E program		BALL STATE						UICSM						SMSG					
Ninth grade science performance level		Low			High			Low			High			Low			High		
Instructional treatment		E	C		E	C		E	C		E	C		E	C		E	C	
Males	Enrolled	19	25	44	27	14	41	17	28	45	32	23	55	37	46	83	49	49	98
	Not enrolled	6	8	14	8	13	21	11	4	15	4	0	4	7	5	12	4	8	12
		25	33	58	35	27	62	28	32	60	36	23	59	44	51	95	53	57	110
		$\chi^2 = .08$			$\chi^2 = 3.30$			$\chi^2 = 4.38$			$p = .15$			$\chi^2 = .34$			$\chi^2 = .62$		
		$p > .70$			$.05 < p < .10$			$p < .05$						$p > .50$			$p > .40$		
Females	Enrolled	16	13	29	32	21	53	23	24	47	30	25	55	36	30	66	56	45	101
	Not enrolled	4	7	11	9	5	14	2	7	9	9	0	9	4	8	12	10	4	14
		20	20	40	41	26	67	25	31	56	39	25	64	40	38	78	66	49	115
		$\chi^2 = .50$			$\chi^2 = 0$			$p = .14$			$p < .01$			$\chi^2 = 1.08$			$\chi^2 = .71$		
		$p > .40$			$p > .95$									$.20 < p < .30$			$p > .30$		
All pupils	Enrolled	35	38	73	59	35	94	40	52	92	62	48	110	73	76	149	105	94	199
	Not enrolled	10	15	25	17	18	35	13	11	24	13	0	13	11	13	24	14	12	26
		45	53	98	76	53	129	53	63	116	75	48	123	84	89	173	119	106	225
		$\chi^2 = .21$			$\chi^2 = 1.58$			$\chi^2 = .50$			$p = .001$			$\chi^2 = 0$			$\chi^2 = .01$		
		$p > .60$			$.20 < p < .30$			$p > .40$						$p > .95$			$p > .90$		

who had not been enrolled in ninth grade science. Since only a very small number of pupils involved in the UICSM comparison had not been enrolled in ninth grade science, the additional comparison was not made for this program. The results of this comparison, shown in Table 7, revealed even smaller E-C differences in tenth grade science enrollment than had been observed for the Ball State and SMSG comparisons for the ninth grade science enrollees.

Table 7

Enrollment in tenth grade science subjects for E and C class pupils not enrolled in ninth grade science

Sex		M		F	
Instructional Treatment		E	C	E	C
Ball State	Enrolled	7	15	14	14
	Not Enrolled	1	2	3	0
SMSG	Enrolled	9	14	22	23
	Not Enrolled	2	3	0	1

The differential enrollment in tenth grade science observed for the UICSM pupils would suggest that this program may have had a deterring effect on pupil decisions in this regard. However, this difference was not consistent with the relatively higher frequency of enrollment in tenth grade mathematics for the UICSM pupils which would seem to be a more sensitive indicator of attitudinal effects of the program on enrollment decisions with respect to subjects involving mathematics. One possibility was that the two decisions were not independent, that for some pupils the decision to enroll in mathematics affected the decision not to enroll in science or vice-versa. That is, a certain proportion of pupils may have decided not to enroll in both math and science subjects but rather to select one or the other. If a relatively higher proportion of such pupils in the UICSM classes chose to enroll in math then a relatively smaller proportion would have enrolled in science which would account for the observed differences.

To determine if this were the case, a tabulation was made considering the tenth grade enrollment in both math and science jointly, disregarding previous performance. This tabulation is shown in Table 8.

Table 8

Frequency of enrollment in tenth grade mathematics and science for pupils instructed with the UICSM and conventional programs.

		E			C		
		Science			Science		
		Not Enrolled	Enrolled		Not Enrolled	Enrolled	
Mathematics							
Males	Not Enrolled	3	4	7	3	17	20
	Enrolled	12	46	58	1	34	35
		15	50	65	4	51	55
Females	Not Enrolled	1	10	11	3	13	16
	Enrolled	10	43	53	4	36	40
		11	53	64	7	49	56

It is apparent that the tenth grade mathematics and science enrollment differences between UICSM and C class pupils occured almost completely among pupils who enrolled in only one of these two subjects. Among pupils enrolled in either math or science, those from the UICSM classes were more likely to enroll in math and those from the C class to enroll in science. Considering just the pupils who enrolled in only one of the two subjects, the degree of association between subject chosen (math or science) and program of instruction (UICSM or conventional) was highly reliable, $\chi^2 = 14.6$, $p < .001$. However, a comparison between the proportion of UICSM and C class pupils enrolled in both subjects indicated that these differences were not reliable either for boys, $\chi^2 = .61$, $p > .40$, or girls, $\chi^2 = .04$, $p > .80$.

Consequently it appears that the differential frequency of tenth grade science enrollment observed in the UICSM comparison occurred only among pupils selecting either math or science and was a result of this differential choice. UICSM pupils more frequently chose mathematics, conventional class pupils more frequently chose science. It seems most reasonable to conclude that for pupils in the UICSM comparison the tenth grade mathematics and science enrollment differences were mainly a result of the ninth grade mathematics program directly affecting the mathematics enrollment decision and thereby affecting the science decision indirectly. That is, the decision with respect to science enrollment followed from the mathematics enrollment decision which was affected by the ninth grade mathematics program.

Performance in tenth grade mathematics

To obtain an indication as to whether the specific program of instruction in ninth grade mathematics might have contributed to performance differences in advanced mathematics subjects, the grades received by the E and C class pupils in their tenth grade mathematics classes were compared.

To control for differences between E and C class pupils with respect to mathematics ability or proficiency existing prior to and independent of the ninth grade program, the tenth grade performance comparisons were made using analysis of covariance with the beginning-of-year ninth grade proficiency test scores as the covariate.

The pupils' ninth grade performance was not considered for this comparison since it was likely that these grades would not be comparable across classes being compared with respect to the pupil characteristics they were reflecting. Also these grades could reflect to some extent the mathematics proficiencies acquired in the ninth grade which it would not be desirable to partial out of the tenth grade performance measure. Consequently, the comparison was made relative to the performance expected on the basis of the pupils level of proficiency at the beginning of ninth grade. The comparison considered pupil sex and type of instructional program (E or C) in a 2 by 2 factorial design for each E program comparison condition.[6]

For analysis of covariance, the covariate regression slope (beta coefficient) for each of the categories being compared (i.e. the separate sex by treatment categories) is assumed to be homogeneous since this slope determines the covariate adjustment to be made on the dependent variable for all pupils. A statistical test was carried out to determine whether this assumption was valid.

The test for homogeneity of slopes indicated that this assumption was tenable for each of the E program comparison conditions. (Ball State, $F_{(3,166)} = 2.06$; UICSM, $F_{(3,116)} = .40$; SMSG, $F_{(3,326)} = .52$) The results of the analysis are shown in Table 9 and the adjusted grade means for E and C class pupils in Table 10.

The analysis indicates that there were no reliable tenth grade performance differences between E and C class pupils for any of the E program comparisons. Statistically reliable sex differences, with girls performing at a higher level, were observed for the UICSM and SMSG comparisons but these were independent of the instructional program, there being no significant sex by program interactions.

These results do not appear to provide any indication that the program of instruction in ninth grade mathematics affected pupil performance in advanced mathematics at the tenth grade level.

[6] For this and subsequent analyses letter grades received in mathematics and in science subjects were assigned the following values: A = 8; A-, B+ = 7; B = 6; B-, C+ = 5; C = 4; C-, D+ = 3; D = 2; D- = 1; F = 0.

TABLE 9

Summary of analysis of covariance on tenth grade mathematics grades.

	Source of Variation	Sum of Squares	d.f.	Mean Square	F
Ball State:	Instructional program	.13	1	.13	.06
	Sex	3.49	1	3.49	1.62
	Program x Sex	.13	1	.13	.06
	Error	364.55	169	2.16	
UICSM:	Instructional program	.12	1	.12	.05
	Sex	18.02	1	18.02	6.81*
	Program x Sex	.01	1	.01	.00
	Error	314.84	119	2.65	
SMSG:	Instructional program	2.60	1	2.60	.85
	Sex	21.75	1	21.75	7.10**
	Program x Sex	.40	1	.40	.13
	Error	1007.69	329	3.06	

TABLE 10

Adjusted mean tenth grade mathematics grades for E and C class pupils.

	Ball State					UICSM					SMSG				
	E		C			E		C			E		C		
	N	$\bar{X}$	N	$\bar{X}$	Ave.	N	$\bar{X}$	N	$\bar{X}$	Ave.	N	$\bar{X}$	N	$\bar{X}$	Ave.
M	49	5.43	46	5.43	5.43	38	4.23	23	4.15	4.19	86	4.62	86	4.51	4.57
F	45	5.78	34	5.67	5.73	37	5.00	26	4.95	4.98	95	5.22	67	4.97	5.10
Ave.		5.61		5.55			4.62		4.55			4.92		4.74	

Performance in tenth grade science

To determine whether the program of instruction in ninth grade mathematics may have had somewhat more general effects on performance in subjects utilizing quantitative concepts and skills, comparisons were also made on the grades received in tenth grade science subjects. These comparisons were carried out following the same covariance analysis procedure used to assess differences in tenth grade mathematics performance. In this instance however, the pupil's performance in ninth grade science was used as the covariate to control for any prior differences in pupil proficiency and motivation with respect to science as a subject matter area.[7]

The adjusted means for the E and C class pupils and the results of the analysis for each of the experimental program conditions are shown respectively in Tables 11 and 12.

Table 11

Adjusted mean tenth grade science grades
for E and C class pupils.

		E		C		
		N	$\bar{X}$	N	$\bar{X}$	Ave.
Ball State	M	46	4.83	40	4.90	4.87
	F	49	5.61	34	5.07	5.34
	Ave.		5.22		4.99	
UICSM	M	49	4.47	51	4.32	4.40
	F	53	5.13	49	5.11	5.12
	Ave.		4.80		4.72	
SMSG	M	86	5.03	95	4.96	5.00
	F	92	5.19	75	5.46	5.33
	Ave.		5.11		5.21	

[7] No science proficiency test data comparable to that for mathematics was available for these pupils.

TABLE 12

Summary of analysis of covariance on tenth grade science grades for the Ball State, UICSM and SMSG program comparisons.

Ball State:

Source of Variation	Sum of Squares	d.f.	Mean Square	F
Instructional program	2.19	1	2.19	1.24
Sex	8.95	1	8.95	5.04
Program x Sex	3.81	1	3.81	2.15
Error	291.01	164	1.77	

UICSM:

Instructional program	.37	1	.37	.17
Sex	26.70	1	26.70	12.21
Program x Sex	.18	1	.18	.08
Error	430.74	197	2.19	

SMSG:

Instructional program	.87	1	.87	.52
Sex	9.36	1	9.36	5.54
Program x Sex	2.28	1	2.28	1.35
Error	579.20	343	1.69	

It can be seen that there were no statistically reliable differences between E and C class pupils for any of the experimental program comparisons with respect to performance in tenth grade science subjects.[8] It does not appear that any proficiency differences developed by the program of instruction in ninth grade mathematics carried over to affect pupil performance in tenth grade science subjects in general.

Discussion

With respect to the effects of the program of instruction in ninth grade mathematics on decisions to enroll in advanced mathematics in the tenth grade, a greater frequency of enrollment was observed among lower ninth grade performance boys instructed with the Ball State program and lower performance boys and girls instructed with the UICSM program when compared to similar pupils in conventional classes taught by the same teachers. No differences in enrollment between E and C class pupils for any of the E programs were observed for higher performance ninth grade pupils, a very large majority of whom enrolled in tenth grade mathematics. There were also no consistent instructional program differences in advanced mathematics enrollment at the eleventh grade level either for those who had or had not enrolled in tenth grade mathematics. The one difference that was observed (a lower enrollment for higher proficiency girls instructed with the SMSG program who had not enrolled in tenth grade mathematics) would seem more likely to be a result of factors other than the attitudinal effects of the ninth grade program since similar differences were not observed for other SMSG program enrollment comparisons that should have been more sensitive to such attitudinal effects. The results obtained for eleventh grade enrollment would seem to indicate that any effects of the ninth grade program on subsequent enrollment were not manifested to any extent beyond the tenth grade level.

Although the pupils for whom tenth grade enrollment differences were observed (lower performance E and C class pupils in the Ball State and UICSM comparison condition) did not now differ with respect to the grades they received in their ninth grade mathematics classes, the E class pupils that exhibited a higher frequency of enrollment were found to have a higher initial level of proficiency as indicated by mathematics test scores. The analysis indicated that this difference could account for some of the enrollment differential. Even though it does not seem likely that the proficiency test scores in themselves would have directly affected the pupils' enrollment decisions in the same way for example that his grades might do so, scores on similar tests may have been used within the school as a basis for recommendations concerning subsequent enrollment, especially for lower performance pupils. Another possibility is that the test scores were reflecting a somewhat higher general academic ability among the E class pupils which in turn would be more likely to be associated with subsequent enrollment in academic subjects. Nonetheless, comparisons made adjusting for test score differences continued to show a somewhat greater but not statistically significant tendency toward enrollment on the part of Ball State and UICSM pupils. For the UICSM

[8] The test for homogeneity of regression slopes in the analysis of covariance indicated that this assumption could not be rejected (i.e. was tenable) in the analysis for each of the experimental program comparisons.

pupils, it was also found that the relatively higher enrollment in mathematics was related to a significantly lower enrollment in tenth grade science subjects. For both mathematics and science subjects the more general enrollment differences were found to be mainly the result of differences in this regard between UICSM and C class pupils who had enrolled in only one of the two subjects, those in the UICSM program tending to enroll in mathematics, those in the conventional program in science. Comparisons for the other experimental programs did not indicate any tenth grade science enrollment differences. Consequently it appears that any affects of the experimental mathematics programs on science enrollment may have been only an indirect result of experimental program effects on mathematics enrollment decisions.

There is a further consideration with respect to enrollment differences and that concerns the pupil's general academic motivation and objectives as well as his initial (pre ninth grade) attitudes toward mathematics and science. No independent information was available concerning these factors which may also have varied between E and C class pupils and contributed to enrollment differences. Consequently it is difficult to conclude that the experimental programs were having any definite effect on pupil attitudes as manifested by subsequent enrollment decisions. At the same time the results do suggest that such effects may have occurred for Ball State and UICSM pupils with respect to mathematics enrollment decisions to the extent that further studies which, in addition, take into account the pupils initial attitudes and motivations should be carried out. It was evident in general, however, that grades pupils had received the previous year were a stronger determinant of subsequent enrollment in mathematics than the specific program of instruction as such.

With respect to performance in mathematics and science subjects at the tenth grade level, there was no evidence provided by the pupils' grades in these subjects that the alternate programs of instruction in ninth grade mathematics had any differential effect. However, here again lack of information concerning factors relevant to pupil motivation, such as general attitudes toward academic achievement and specific attitudes toward mathematics, precludes drawing any unequivocal conclusions with respect to the effects of these instructional programs on subsequent performance in relevant areas. Another consideration with respect to performance in tenth grade mathematics is that for a large majority of pupils the tenth grade mathematics subject in which they were enrolled was geometry. It is quite likely that geometry does not require a high degree of application or utilization of the specific knowledge or proficiencies acquired in ninth grade algebra, and consequently performance therein would not be as sensitive to variations in the ninth grade instructional program.

Summary

This study was carried out to determine whether any of several experimental programs in ninth grade algebra (Ball State, UICSM, SMSG) differentially affected pupils attitudes toward mathematics as manifested by subsequent enrollment in tenth and eleventh grade advanced mathematics and science subjects. The analysis also considered the effect of the experimental programs on pupil performance (grades received) in tenth grade math and science subjects. The sample consisted of pupils in 21 pairs of ninth grade algebra classes, each pair of classes having been taught

by the same teacher, one class with one of the E programs, the other with a conventional program.

Comparisons were made for each E program between pupils in the paired E and C classes with respect to frequency of enrollment in tenth and eleventh grade advanced mathematics subjects and tenth grade science subjects and with respect to grades received in the tenth grade mathematics and science subjects. Previous pupil performance (grades) and mathematics proficiency test scores were considered in the comparisons which were made separately for each sex.

Some evidence of a higher frequency of enrollment in tenth grade mathematics for pupils instructed with the Ball State and UICSM programs was obtained. For the UICSM pupils a related tenth grade science enrollment difference was found.

For none of the E program comparisons was a difference observed between E and C class pupils with respect to performance in subsequent mathematics and science subjects.